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The effect of walking faster on people with acute low back pain

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Abstract Little is known about self-selected speed and fast walking in people with acute low back pain. This study aimed to investigate (1) the strategies that people with acute low back pain use to change from self-selected speed to fast walking and (2) the effect of a period of treadmill walking on level of back pain. Eight participants with acute low back pain and eight matched control participants were evaluated during self-selected speed and fast walking on a treadmill. The eight participants with back pain were retested 6 weeks later when pain had resolved. Measurements were taken of (1) three-dimensional angular movements of the pelvis and lumbar spine using a videoanalysis system, (2) the timing and distance parameters of walking, and (3) pain levels as measured by a visual analogue scale. We found that to walk faster, those with acute low back pain increased stride length and the frontal plane movements of pelvic list and lumbar lateral flexion (pelvis) to a greater extent than when symptoms had resolved. We also found that 10 min of treadmill walking at self-selected speed led to a reduction in the level of back pain and that there was a high degree of negative correlation between level of back pain and stride length. An additional 5 min of fast walking did not lead to any further changes in level of back pain. These findings support clinical recommendations that the moderate physical activity of walking may be beneficial in the management of people with acute low back pain. To walk faster, people with acute low back pain may utilise strategies that had been limited at self-selected speed, without any increase in pain.

Keywords Walking · Range of motion · Pelvis · Spine · Low back pain

Introduction

Walking is a functional activity that is commonly affected in people with low back pain [24, 38]. Although there is accumulating evidence that movements of the pelvis and lumbar spine play an important role in unimpaired gait [7, 14, 18, 19, 28, 30, 32, 36, 40], little is known about how back pain affects these movements.

A recent study found that the differences in pelvic and lumbar movements during self-selected speed walking between those with and without back pain were relatively small [31]. The movement deficits of people with back pain might become more apparent during the change from self-selected speed to fast walking, when extra demands are placed on the locomotor system. In people without impairment, fast walking has been associated with increased stride length and cadence [43] and increased transverse-plane movements of the lumbar spine (relative to the pelvis) [8]. There is evidence that people with chronic low back pain find it difficult to increase the transverse plane rotations of the thorax when increasing walking speed

[25]. It can be hypothesised that during fast walking, people with back pain might demonstrate greater limitation of pelvic and back movements to minimise stress on the pain-sensitive structures of the lumbar spine than people without pain. The main aim of this study was to test this hypothesis in a group of people with acute low back pain by comparing them with a control group without back pain and by comparing them with themselves 6 weeks later, when it was expected the that pain would have resolved.

Patients with acute low back pain are often advised to undertake moderate exercise, such as walking. For example, the Royal College of General Practitioners [20] recommend that patients with low back pain be advised to stay as active as possible and to continue normal daily activities. Such findings are based partly on studies demonstrating that patients with acute low back pain given advice to remain active did better than those treated with medication or formal back exercises [15] and partly on the consistent findings that prolonged bed rest does not help in the resolution of low back pain [42]. Therefore, the second aim of this paper was to investigate the effect of a period of treadmill walking on low back pain, to determine whether evidence could be provided to support clinical recommendations that moderate activity, such as walking, may be beneficial in the management of acute low back pain.

Materials and methods

Participants

Eight participants with acute low back pain and eight matched (for gender, age and height) control participants were recruited and gave informed consent to participate in the study, which had gained approval from the faculty ethics committee. Each participant with back pain met the criteria of the Quebec Task Force classification scheme as category 1a or 2a, with pain not extending beyond the knee and of less than 7 days' duration, with no neurological signs, no history of spinal surgery and no history of spinal stenosis [27]. Matched control participants were required to be free from pain at the time of the study and be without history of low back pain in the previous 2 years.

Apparatus

The video-based Peak three-dimensional motion measurement system (version 5.2) (Peak Performance Technologies, Englewood, Colo.) was used to measure the three-dimensional angular movements of the pelvis and lumbar spine of each participant walking on a treadmill. Two videocameras, taping at a rate of 50 fields per second, were used to track the movement of surface markers. The data were smoothed using a fourth-order zero-lag digital Butterworth filter with low-frequency cut-off at 5 Hz.

The videocameras recorded movements of eight retroreflective markers. Pairs of markers represented segments from which the angular movements of the pelvis and lumbar spine were subsequently calculated. The retroreflective markers were 1 cm in diameter and were attached to lightweight, thermoplastic rigs or directly to each participant's skin at the level of the first lumbar spinous process and the base of the sacrum.

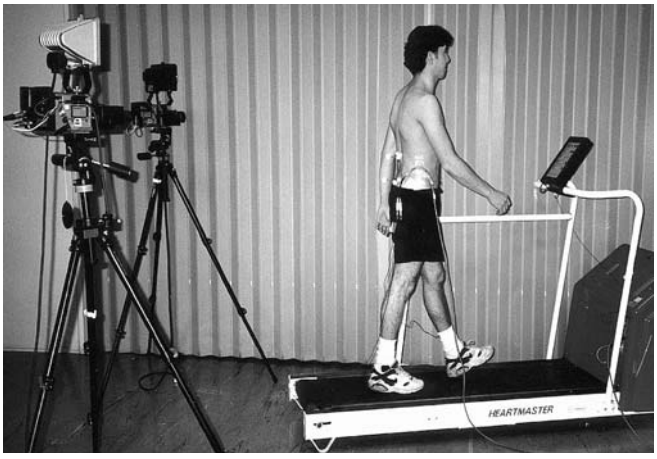

Fig. 1 Participant walking on treadmill with markers in place, while being videotaped by two cameras. *Note:* cameras were placed closer to the participant for the purposes of this photograph

To record events of the gait cycle, participants wore pressure sensitive insoles inside flat, lace-up shoes while walking both overground and on the treadmill. The movements of the pelvis and lumbar spine were measured while each participant walked on a treadmill driven by an electric motor of 1.1 kW power and walking area of 1.69×0.45 m ("Heartmaster Mark 3B", Tetley Technologies, Caringbah, Australia). The apparatus, shown in Fig. 1, has been more fully described elsewhere [33].

Procedure

To determine self-selected walking speed, all participants walked on a level overground 10-m walkway. Participants were instructed to "Walk at your normal comfortable speed right to the end of the walkway". Following one familiarisation walk, self-selected walking speed for each participant was determined over the middle 6 m of the walkway using a stopwatch.

After determination of self-selected speed, the thermoplastic rigs and retroreflective markers were attached and participants started treadmill walking. Participants were allowed to hold onto the handrails as the treadmill started, but were encouraged to use normal arm swing as they familiarised to treadmill walking. All participants were able to walk on the treadmill without using the handrails within 1 min of the treadmill starting.

Each acute low back pain participant walked on the treadmill for 10 min at self-selected speed, as determined on the level overground walkway. Self-selected speed was chosen as it has been found to correspond with the most energy-efficient walking speed [23]. After resting for 2 min, participants walked on the treadmill for a further 5 min at fast speed. The speed of the fast walking trial was calculated by increasing each participant's self-selected speed by 40% to approximate the expected self-selected speed if the participants were unaffected by low back pain [12, 13]. A ceiling of 116.7 $m.min^{-1}$ (7.00 $km.h^{-1}$) for fast walking was set, as running is often the most comfortable mode of locomotion above this speed [35]. When re-tested 6 weeks later, the same back pain participants completed 5 min of treadmill walking at self-selected speed followed by 5 min at fast speed. Each control participant also walked on the treadmill for 5 min at self-selected speed followed by 5 min at fast speed.

Data were collected after 4 min of continuous treadmill familiarisation during each treadmill trial. It has been demonstrated that reliable measurements of the pelvis and lumbar spine can be taken after 4 min of treadmill familiarisation [32].

Assessment parameters

Angles were derived from rotations of vectors from the marker sets projected onto the three planes of the global reference frame, as defined by the placement of the treadmill. Lumbar angles were measured both relative to the pelvis and relative to the global reference frame (global lumbar angles). Each angular movement of the pelvis and lumbar spine was the amplitude (maximum angle minus minimum angle during a gait cycle) averaged over six completed gait cycles. A more detailed description of angle definition can be found elsewhere [33]. An advantage of using a projected angles method is that it will produce results consistent with the qualitative description of movement observed by the clinician. Using a projected angles method, we have found the effect of out-of-plane lumbar movements during walking, on average, to be less than 0.27° [32].

The following timing and distance parameters of gait were measured: speed, cadence (steps per minute) and stride length (distance covered in one complete gait cycle). Speed was recorded from the digital display of the motorised treadmill, which did not differ from actual belt speed by more than 0.7 $m.min^{-1}$, with 95% confidence.

All participants completed a pain score while standing still on the treadmill before and immediately after the treadmill walking trials at self-selected and fast speeds. The pain score was determined on a 10-cm vertical visual analogue scale with the anchor 'no pain' at the bottom and the anchor 'pain as bad as it could be' at the top. Participants were asked to mark their estimated level of pain 'at the moment'. From the mark on the visual analogue scale a pain score was measured in millimetres from the bottom of the scale. Participants were not shown their previous pain scores. In the acute low back pain group, pain scores assessed twice before starting treadmill walking were highly stable (intraclass correlation coefficient=0.99). The status of the episode of acute back pain was also documented by measuring disability (Roland-Morris questionnaire) [22] and restriction of sagittal plane flexibility (finger tip to floor) [16].

Statistical analyses

The changes between fast and self-selected speed walking were calculated for the amplitude of the angular movements of the pelvis and lumbar spine, and for speed, cadence and stride length. Paired *t*-tests on the change between self-selected speed and fast walking were used to compare the back pain participants in the acute stage and 6 weeks later. Independent *t*-tests on the change between self-selected speed and fast walking were used to compare the acute back pain and control groups, and to compare the back pain participants tested 6 weeks later with the control group. Comparison of change with *t*-tests is mathematically equivalent to examination of the interaction effect with analysis of variance [29].

The comparison of pain levels in participants with acute low back pain before and after 10 min of self-selected speed walking and after a further 5 min of fast walking was assessed using Wilcoxon's signed-rank sum test. The relationship between pain level and stride length was examined with Spearman's rank order correlation coefficient (r_s). The level of significance was set at P=0.05.

Results

Participants

There were no significant differences between the acute low back pain and control groups in age [experimental 33.5 years (SD 8.8 years), control 33.3 years (SD 8.4 years), t (14)=0.06, P=0.96], height [experimental 175.1 cm (SD 13.5 cm), control 175.0 cm (SD 13.5 cm), t (14)=0.02, P=0.99] and weight [experimental 74.1 kg (SD 20.2 kg), control 71.8 kg (SD 17.5 kg), t (14)=0.25, P=0.81].

The eight participants were tested within 7 days of onset of their episode of low back pain (mean=2.3 days, SD 1.6 days) and re-tested approximately 6 weeks later (mean=45.1 days, SD 2.1 days). In the acute phase, three participants were classified according to the Quebec Task Force classification scheme as category 2a, with pain extending beyond the gluteal fold but not beyond the knee, and five participants were classified as category 1a, with pain not extending beyond the gluteal fold [27]. The status of the episode of acute back pain was documented by pain level (100 mm visual analogue scale, median=36.5 mm, interquartile range 14.5–73.5), disability (Roland-Morris questionnaire, median=8.5, interquartile range 5.5–13.5) and restriction of sagittal plane flexibility (finger tip to floor, median=35 cm, interquartile range 10–51). Data were lost for one participant with acute low back pain at fast walking speed due to the greater excursion of marker movement causing multiple markers to be out of the cameras' field of view. Therefore, data for the angular movements of the pelvis and lumbar spine during fast walking were based on seven subjects with acute low back pain.

On re-testing after 6 weeks, the eight participants had resolved from the episode of low back pain. Not one of the eight participants reported any back pain and only two of the eight participants reported low levels of disability (Roland-Morris questionnaire, median=0, interquartile range 0–0.5). Sagittal plane flexibility also demonstrated a significant increase on re-testing (finger tip to floor, median=14 cm, interquartile range 0–20) (Wilcoxon's signed-rank sum test, z=2.5, P=0.01).

Angular movements of the pelvis and lumbar spine

Changes in the angular movements of the pelvis and lumbar spine with faster walking are shown in Table 1. As participants with acute low back pain changed from self-selected speed to fast walking, there was a trend to greater increases of movements of the pelvis and lumbar spine (relative to the pelvis) compared with when symptoms had resolved. There were greater increases in pelvic list [mean difference=1.9°; t (6)=2.65, P=0.04] and lumbar lateral flexion [mean difference=2.3°, t (6)=2.66, P=0.04] in response to walking faster in participants with acute low back pain compared with when symptoms had resolved. There were no trends or statistically significant differences in change between acute low back pain and control groups for any of the nine angles. Only one comparison between the resolved and control groups reached significance, with the control group increasing the amplitude of pelvic axial rotation more with fast walking than

Table 1 Change (mean and standard deviation) in the angular movements of the pelvis and lumbar spine (in degrees) between self-selected speed and fast walking for participants with acute low back pain, resolved low back pain and those without a history of back pain (controls). Positive change indicates an increase in amplitude with fast walking

	Acute			Resolved			Control		
	Change	Self-selected	Fast	Change	Self-selected	Fast	Change	Self-selected	Fast
Pelvic list	3.6 (2.7)*	9.0 (3.0)	12.6 (3.8)	1.8 (1.3)	11.7 (5.9)	13.5 (5.9)	2.7 (1.4)	9.7 (2.3)	12.4 (1.8)
Pelvic axial rotation	3.7 (4.9)	6.7 (1.5)	10.4 (4.6)	2.0 (3.4)**	10.8 (5.4)	12.9 (7.6)	5.3 (2.6)	9.4 (3.9)	14.7 (5.3)
Pelvic tilt	1.2 (1.0)	3.4 (1.0)	4.6 (1.0)	1.9 (1.7)	5.2 (2.9)	7.0 (3.1)	1.1 (1.9)	3.1 (1.3)	4.2 (2.8)
Lumbar lateral flexion (pelvis)	4.0 (2.8)*	8.4 (3.6)	12.4 (4.7)	1.7 (1.9)	13.1 (6.8)	14.8 (6.5)	2.2 (1.6)	10.2 (3.1)	12.4 (3.0)
Lumbar axial rotation (pelvis)	2.0 (2.5)	5.7 (1.1)	7.7 (2.4)	2.5 (1.9)	6.8 (3.4)	9.3 (3.6)	1.3 (0.9)	6.2 (1.8)	7.6 (2.0)
Lumbar flexion/ extension (pelvis)	0.7 (1.0)	3.1 (1.6)	3.8 (1.3)	2.0 (1.0)	4.4 (1.3)	6.4 (2.3)	0.9 (2.2)	3.4 (1.6)	4.3 (2.6)
Lumbar lateral flexion (global)	0.9 (0.8)	3.3 (1.4)	4.2 (1.9)	1.0 (1.5)	3.6 (1.3)	4.7 (1.5)	0.4 (1.0)	3.1 (1.4)	3.4 (1.1)
Lumbar axial rotation (global)	1.5 (4.1)	8.8 (2.4)	10.2 (3.7)	1.7 (2.6)	9.3 (4.0)	10.9 (4.3)	3.6 (2.0)	10.2 (3.9)	13.7 (4.3)
Lumbar flexion/ extension (global)	–1.0 (1.4)*	3.5 (1.3)	2.6 (0.7)	0.7 (0.6)	2.2 (0.9)	2.9 (0.8)	–0.1 (2.4)	2.9 (0.6)	2.9 (1.4)

*$P<0.05$, two-tailed, acute versus resolved change scores; **$P<0.05$, two-tailed, resolved versus control change scores

did the group with resolved back pain [t (14)=2.16, P=0.049].

For lumbar movements relative to a global reference frame there was a significant difference between the acute and resolved conditions in the change for flexion/extension [mean difference=1.7°, t (6)=3.60, P=0.01].

Timing and distance parameters of walking

Changes in speed, stride length and cadence for acute and resolved low back pain participants and the control group walking 40% faster than self-selected speed are shown in Table 2. As expected, there were no significant differences in the increase of walking speed between either the acute and resolved participants [t (7)=1.37, P=0.21] or the acute and control groups [t (14)=1.58, P=0.14].

Those with acute low back pain increased walking speed by increasing stride length more than these participants did when their pain had resolved [mean difference=0.11 m, t (7)=5.60, P=0.0008]. There was no significant difference in the change in stride length between the acute group and the control group, or between the resolved and control groups. From viewing the values in Table 2, it can be seen that participants with acute low back pain took shorter strides than when symptoms had resolved at both self-selected [t (7)=7.49, P=0.0001] and fast walking speeds [t (7)=2.93, P=0.02]. There were no significant differences found for changes in cadence with fast walking between any of the groups.

Table 2 Change (mean and standard deviation) of speed, stride length and cadence between self-selected speed and fast walking for participants with acute low back pain, resolved back pain and control participants. Positive change indicates increased speed, stride length and cadence with fast walking

	Acute			Resolved			Control		
	Change	Self-selected	Fast	Change	Self-selected	Fast	Change	Self-selected	Fast
Speed ($m.min^{-1}$)	28.6 (2.7)	77.6 (9.0)	106.2 (9.2)	24.2 (7.6)	90.7 (9.9)	114.8 (7.4)	31.9 (2.7)	79.9 (5.1)	111.8 (6.2)
Stride length (m)	0.30 (0.08)*	1.36 (0.16)	1.66 (0.12)	0.19 (0.13)	1.57 (0.11)	1.76 (0.15)	0.28 (0.04)	1.44 (0.10)	1.72 (0.11)
Cadence ($steps.min^{-1}$)	13.4 (6.4)	115.0 (11.2)	128.4 (13.5)	15.3 (4.4)	115.8 (12.9)	131.1 (13.8)	18.7 (3.5)	111.8 (3.9)	130.5 (6.1)

*$P<0.05$, two-tailed, acute versus resolved change scores

Pain level following walking with acute low back pain

There was a significant reduction in reported pain levels with acute back pain participants after 10 min of self-selected speed walking (Wilcoxon's signed-rank sum test, z=2.40, P=0.02), with the median visual analogue scale score of 36.5 (interquartile range 14.5–73.5) at the start reducing to a median score of 18.0 (interquartile range 11.5–64.5). After a further 5 min of fast walking, there were no apparent or statistical changes in pain levels (Wilcoxon's signed-rank sum test, z=0.49, P=0.62), with self-reported pain levels at the end of fast walking of median 16.5 (interquartile range 14.0–63.0).

There was a high degree of negative correlation between pain level just prior to the treadmill walking trial and stride length during the self-selected speed trial (r_s= –0.97, P=0.01). There was a strong trend that the change in pain level after 10 min of walking at self-selected speed was negatively correlated with the subsequent increase in stride length with fast walking (r_s=–0.59); however, this trend did not reach statistical significance (P=0.12).

Discussion

The findings, in acute low back pain participants, of greater increases in the amplitude of lumbar lateral flexion (relative to the pelvis), pelvic list and stride length in order to walk faster was unexpected. Our findings are contrary to those of Selles et al. [25]. However, they studied a group of people with chronic low back pain, in contrast to our study, which investigated a group of people with acute low back pain, within 7 days of onset.

These findings, of greater increases in the frontal plane movements and stride length in acute low back pain participants in order to walk faster, can be understood by considering the strategies that acute low back pain participants employed at self-selected speed. At self-selected speed, acute low back pain participants had significantly reduced amplitude of lumbar lateral flexion and pelvic list, and significantly reduced stride length when compared with when symptoms had resolved [31]. It seems acute low back pain participants had already employed the hypothesised strategies of reducing pelvic and spinal movement and reduced stride length in order to walk at self-selected speed. When further demands were placed on the system by requiring participants with acute low back pain to walk faster, the strategies of increasing the frontal plane movements of the pelvis and spine and increasing stride length were available to a greater degree than they were in the same participants when pain had resolved. There is evidence that there is less redundancy in faster walking compared with self-selected speed walking. Crosbie and Vachalathiti [6], and van Emmerik and Wagenaar [39] have demonstrated more tightly co-ordinated and less variable hip, pelvic and trunk movements during fast walking.

The finding of reduced pain following a period of self-selected speed walking for acute low back pain participants provides empirical evidence to support the notion that moderate levels of activity can be beneficial in the management of acute non-specific mechanical low back pain. This finding complements accounts of the positive effect of walking on low back pain seen in anecdotal accounts [4], case reports [26], or indirectly, where walking played some part in a general activity and fitness programme [2, 3, 10, 11, 34]. Also, it suggests that the response to walking might be useful in the classification of low back pain patients. Specific sub-groups of other categories of low back pain such as spinal stenosis [9], lumbar instability [37] and more serious pathology [21] have been reported to demonstrate increased symptoms with walking, in contrast to the non-specific mechanical acute low back pain investigated in this study.

The finding of a strong negative correlation between level of pain and stride length during self-selected speed walking may have important theoretical implications. Although correlation does not infer causation, it could be hypothesised that stride length regulation in acute low back pain might be a fundamental response to dealing with level of pain, by minimising ground reaction forces. The relationship between ground reaction forces and stride length has been demonstrated [1], and the effect that the transmission of these forces can have on the control of the head and trunk has been described in people without pathology [5, 44]. The importance of minimising transmission of forces through the spine in people with back pain has also been demonstrated [41]. This minimisation of forces through the spine in people with back pain might be accomplished by reducing stride length.

Despite using the strategies that had been inhibited during self-selected speed walking, there was no apparent exacerbation of symptoms with fast walking. That is, when a participant with acute low back pain walked faster with increased stride length and with increased frontal plane movements of the pelvis and lumbar spine, it was achieved without increasing the level of back pain.

This raises the question of why these gait strategies might be inhibited in people with acute low back pain walking at self-selected speed if their employment does not lead to increased pain. Participants with acute low back pain may walk with a shorter stride and with back movements limited or "splinted" due to a fear of increasing pain. Alternatively, walking with the back relatively splinted and a shorter stride may give the person with back pain a greater margin of safety to deal with any unexpected perturbations during walking.

These results raise interesting questions that require further research. There are many dimensions to the domain of pain apart from pain intensity as assessed by a visual analogue scale. Therefore, a full description of the effect of walking on low back pain might require a measurement instrument, such as the McGill pain questionnaire, which

takes account of sensory-discriminative, motivational-affective and cognitive-evaluative dimensions of pain [17]. This experiment does not reveal whether the effect of pain reduction was maintained over time or whether it helped to lead to a quicker recovery. Also, if walking helps to reduce low back pain, this finding does not address what levels or protocols of walking might lead to optimum reduction of pain.

A further limitation of these results was the relatively small sample size. However, there were statistically significant results, suggesting sufficient power. Also, the results of this experiment can only be generalised to acute back pain of less than 7 days duration with pain not radiating beyond the knee. Further research is required to determine the effects of fast walking on other important categories of back pain, such as back pain associated with neurological changes.

Conclusion

In summary, the main finding of this paper was that participants in acute low back pain used different strategies to walk faster than did the same participants when symptoms had resolved. Acute low back pain participants increased the frontal plane movements of pelvic list and lumbar lateral flexion and stride length to a greater extent. To walk faster, participants with acute low back pain utilised strategies that had been limited at self-selected speed.

The second main finding of this paper was that a period of 10 min walking on a treadmill at self-selected speed led to a reduction in the level of back pain, and that a further 5 min of fast walking did not lead to any further reduction in level of back pain. This finding provided limited empirical evidence to support clinical recommendations that the moderate physical activity of walking may be beneficial in the management of people with acute low back pain. The strong negative correlation between level of pain and stride length suggests that regulation of stride length might be an important response to pain in people with acute low back pain. There is a need to thoroughly investigate the effect of walking on back pain with further study.

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